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*The application of artificial intelligence principles to teaching and training**

Keith Shaw

Keith Shaw is a consultant to a number of companies and government agencies in the use of computers in training. After graduating in Chemistry in 1968, he taught for six years, during which time he pioneered the use of computer-based models and simulations in chemistry teaching and gained a Master's degree in Education, specialising in the application of theories of learning to the analysis and solution of learning problems. In 1974 he moved to lecture at Sheffield Polytechnic and established a Centre for Computer-based Learning which serviced several undergraduate courses and provided computer-based training consultancy and courseware design to industry. He also travelled extensively in Europe, North America and Australia, lecturing on and researching in the uses of computers in education and training. In 1982, with three associates, he formed SYSTEM ('South Yorkshire Systems for Training, Education and Management Ltd) to develop the commercial potential of his academic activities. SYSTEM obtained an Alvey grant to work with the Open University on the application of artificial intelligence and expert systems to some fundamental problems of mathematics education. Keith Shaw was elected a member of the British Computer Society in 1984. Address for correspondence: 120 Townhead Road, Dore, Sheffield S17 3GB, UK. Email: keith@keithshaw.co.uk

Abstract

This paper compares and contrasts the use of AI principles in industrial training with more normal computer-based training (CBT) approaches. A number of applications of CBT are illustrated (for example simulations, tutorial presentations, fault diagnosis, management games, industrial relations exercises) and compared with an alternative approach using AI. An evaluation of the relative merits of the two approaches will be given. Existing CBT packages are used to illustrate the points raised and the emphasis of the arguments will be on the effectiveness of AI and CBT in terms of both cost and learning. The position of AI applications within CBT is discussed, as is the task of getting started in applying these techniques.

AI might be simplistically described as an attempt to use computers to mimic the functioning of human intelligence and may include knowledge acquisition, reasoning and adaptation to experience. However, the realisation of such a concept lies in the future. Current experimental developments use large, fast and expensive computers. There are many problems still to be identified and solved, not the least of which is what

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type of software to use for the development of AI applications. Applications are available today, however, which are respectably powerful subsets of AI, typically cost about £1000, are implemented on desktop microcomputers and have a significant role to play in training. Such a subset is an expert system.

Expert systems are computer programs which represent explicit human knowledge, are capable of explaining their reasoning and are easily modified.

The justification for applying expert systems techniques to training can be stated very simply: they allow you to do some things which could not be done any other way, or could not be done as economically or as effectively. Implicit in this is the claim that expert systems, properly applied to training, can:

- significantly enhance existing training;
- produce cost savings;
- alleviate or avoid the consequences of failure provide effective training.

Examples of computer-based training (CBT) were analysed to see how they could be enhanced through the application of expert systems. All the examples tested were of well-acclaimed courseware which has been validated and is in wide use within the organisation for which they were produced. The expert systems approach is therefore being measured against good-quality courseware.

A comparison of a videotape and a CBT fault-finding exercise on an industrial plant illustrated one essential difference in the approach which expert systems make possible; they can be used for guidance and counselling far more effectively than the more usual CBT approaches. There is, however, a clear similarity of style between the fault-finding approach and many expert systems approaches and the question then arises as to which is superior. Part of the answer lies with the types of application for which expert systems are not suitable. They are not particularly good for simulation work and setting up 'what happens if ...' investigations. They are, however, very good where:

- advice is required;
- explanations or reasons for decisions are desirable;
- the ability for the trainee to identify the chain of reasoning is useful;
- the advice of, or consultation with, an expert or experienced person would improve effectiveness in use;
- further enhancement is envisaged.

An analysis of an expert system application for the application of rules and regulations governing statutory sick pay illustrated that expert systems can provide these features more readily and more cheaply than many authoring languages for CBT. They also have an additional advantage. Most CBT, when written in a standard authoring or programming language, presents a fixed approach to a topic and once the training has taken place there may be little value in retaking the training course. With expert systems, however, the material can be designed to be part of the initial training and to then

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provide ongoing support after the training has finished by way of their expert consultant facilities.

A videotape presentation of an expert system used in the role of counsellor and advisor demonstrated that expert systems can also be designed to provide, through their role of expert consultant, continuous on-the-job training and enhancement of performance. This can be tailored for use by the novice, the experienced and the expert employee alike. The value here lies not merely with the increase in efficiency deriving from the constant availability of the expert tutor, but also from the rapid (and almost incidental) acquisition by the trainee of the expert knowledge of the expert system. Once the tremendous potential of this aspect of expert systems is recognised it will be apparent that there is a very diverse range of applications where an expert system, taking on the role of the expert counsellor, can be used to provide ongoing training in the work environment. This avoids the costs associated with removing personnel from their work and transporting them to central training locations, but does assume the availability of appropriate hardware, such as IBM PCs at the work locations.

The expert counsellor will also be available to provide advice in the future—to be used for refresher training, consolidation of knowledge and experience or for reference on specific issues. These are features which are very difficult to achieve by other CBT methods. A second example of CBT, this time in the realm of the selection and use of measurement devices in chemical engineering, illustrates these points.

This approach is satisfactory for producing an awareness level of competence, but it cannot guarantee understanding or retention of information or the accurate and appropriate application of that knowledge. Replace, or better still add to, this piece of CBT with an expert system containing the new knowledge, but is structured to:

- offer advice on either general or specific issues and circumstances;
- explain the reasons for its advice;
- prescribe the alternatives available and the circumstances in which they would be used;
- offer the option to explore a range of features of the problem and their implications;
- explain the consequences of wrong decisions;

and you have a vastly superior, powerful and useful piece of training material. Furthermore, you have a knowledge based on expert information which can be amended relatively easily in circumstances such as when changes in legislation, engineering practice or technological innovation occur.

The expense, time and manpower resource required to achieve the same result by standard CBT techniques would be quite prohibitive. In addition the tasks of specifying, designing, implementing, debugging and maintaining such a CBT package would be immense, and later amendment or enhancement would be extremely difficult. Expert systems techniques, however, allow all of the previously mentioned possibilities to be achieved quickly and economically.

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A CBT package dealing with the acquisition of finance for business expansion adequately reinforces the major features of assembling and presenting a case for business funding and provides for appropriate practice in the decision making and management required for a successful application. However the sources of finance are many, as are the types of business for which the finance is required and a simulation of this type cannot hope to cover all the permutations, regulations or eligibility criteria associated with such a complete problem. The simulation plays an extremely valuable role in introducing the trainee to the general issues of, and procedures for, raising finance, but does not help with specific circumstances. It is here that an expert system would be extremely valuable in providing advice about the types of finance available, eligibility criteria, methods of application, timescales, etc. Furthermore, once such an expert system has been developed, it is relatively easy to amend it as criteria change or to add new features as additional sources of finance, such as EEC grants, are introduced.

So far only the virtues of expert systems have been promoted in this paper. There are a number of problems associated with implementing expert systems just as with any technology-based training medium; for example, expert systems are quite limited in what they can do and in the role they can play in training. This was mentioned earlier but, to elaborate, an expert system may be appropriate if:

- an extensive body of expertise exists;
- there is a significant need for that expertise;
- there are few experts available;
- it is difficult to acquire new experts;
- the cost of making a mistake is high.

In the training context, expert systems rise to material of the style:

'What should I do ...';
'How do I ...';

but not usually:

'What happens if ...'.

Another cause for caution is that the medium is still in its infancy and care is needed to avoid making false claims for its current capabilities. Expert systems are not usually as easy to build as CBT packages using authoring languages, although several sources claim that development costs are comparable; the difference lies in the types of skills required. To develop expert systems one needs:

- a subject expert who is keen, available, articulate and authoritative
- appropriate 'software tools' such as expert systems shells
- expert advice and guidance on the use of the tools
- appropriate hardware (eg, IBM PC or equivalent).

Although there are many software tools or 'shells' being marketed with the claim that they can be used effectively by novices, this should be treated with caution. It is,

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however, interesting to note a finding from a recent report of the Alvey Directorate that: 'Simpler expert systems are practical and being implemented now by self-taught teams, with little risk, at relatively low cost to produce modest but unusual gains'.

Another interesting feature is that they can be highly effective in generating motivation and other positive attitudes as well as facilitating knowledge acquisition. The importance of such effective objectives is frequently overlooked in a training environment often dominated by statements of objectives in purely behavioural terms. Furthermore, knowledge acquisition is an inevitable consequence of the use of expert systems. They act as a support agent during learning and in the real work environment until, by virtue of the increased competence of the trainee, they make themselves redundant. What more could be asked of a training medium?

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